# New Result Shows Separation of Time Scales in Rotating and Stratified Flows at High Latitudes

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Earth's high latitudes (Fig. 1) stand to be among the first regions affected by climate change issues due to changes induced by melting ice in the Arctic and Antarctic. The dynamics in the high latitudes is affected by the higher rotation rate as measured by the Rossby number. The smaller the Rossby number, the more important the rotation is to the dynamics. Motivated by gaining fundamental understanding of ocean dynamics at high latitudes, we have derived new results based on the method of multiple scales presented in [1], which address the scale separation between slow- and fast-time scale dynamics in the limit of fast rotation while retaining order one effects due to stratification. This paper has been submitted for publication [2]. The result is important because it leads to new equations for the slow dynamics.

The principle results are:

- Finding that as the rotation rate increases, the fast and slow dynamics decouple.
- Development of new equations for the slow dynamics that include conservation laws of the slow variables. One important consequence of the new slow equations is that the horizontal and vertical kinetic energy decouple and conserve their kinetic energy independently.

Figure 2 shows the potential enstrophy as a function of the Rossby number for numerical simulations of high wave number forcing numerical experiments [3]. As the Rossby number decreases (or the rotation rate increases), the potential enstrophy becomes entirely slow. Figure 3 shows the horizontal kinetic energy as a function of the Rossby number. As the Rossby number decreases, the time rate of change of the vertical kinetic energy approaches zero.

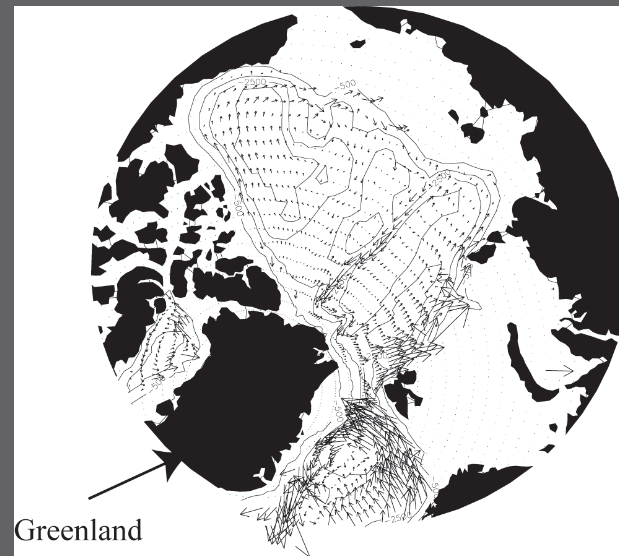


*Fig. 1. A top view of the Arctic Ocean (Hunke et al., 2007)*

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[1] P. Embid and A. Majda, *Geophysical and Astrophysical Fluid Dynamics,* **87,** 1-50 (1998).
[2] B. Wingate, M. Holmes, M. Taylor submitted to *Journal of Fluid Mechanics* (2007).
[3] L. Smith and F. Waleffe, *Journal of Fluid Mechanics,* **451,** 145-168 (2002).

Reference
E. Hunke and M. Holland, *Journal of Geophysical Research,* **112,** c06S14 (2007).

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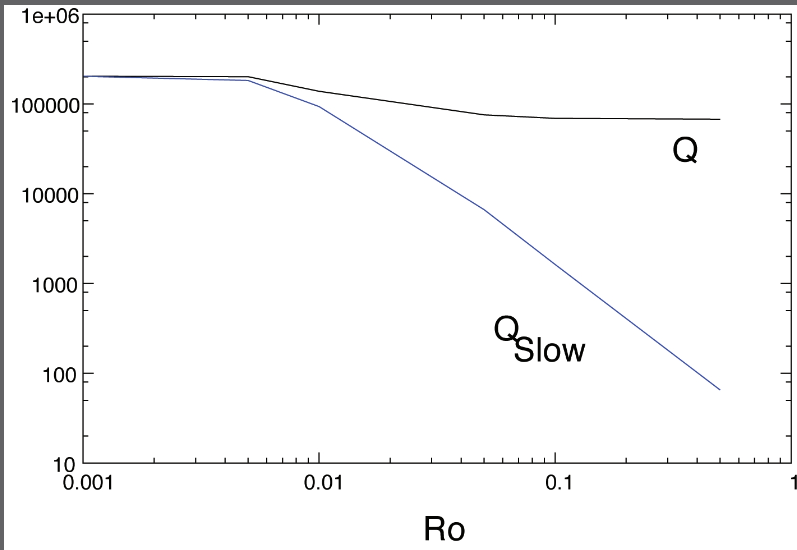


*Fig. 2. The potential enstrophy as a function of Rossby number. As the Rossby number decreases, the total potential enstrophy becomes entirely slow.*

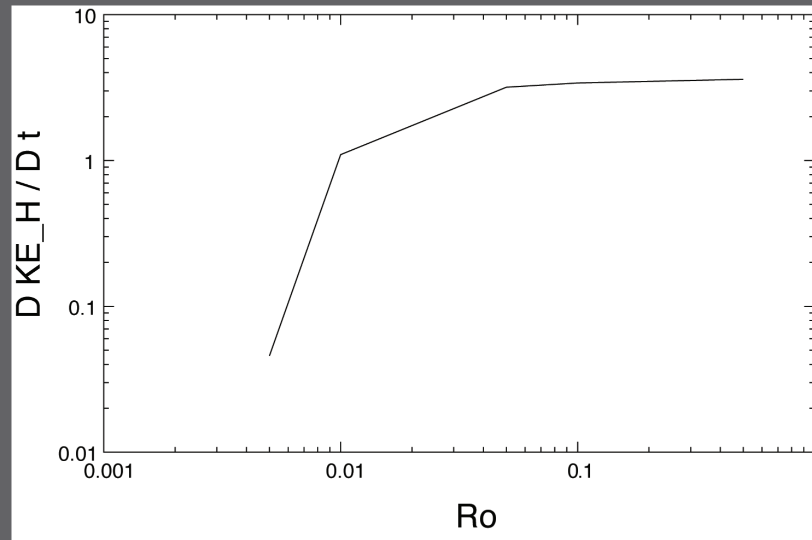


*Fig. 3. The time rate of change of the horizontal kinetic energy approaches zero as the Rossby number decreases.*